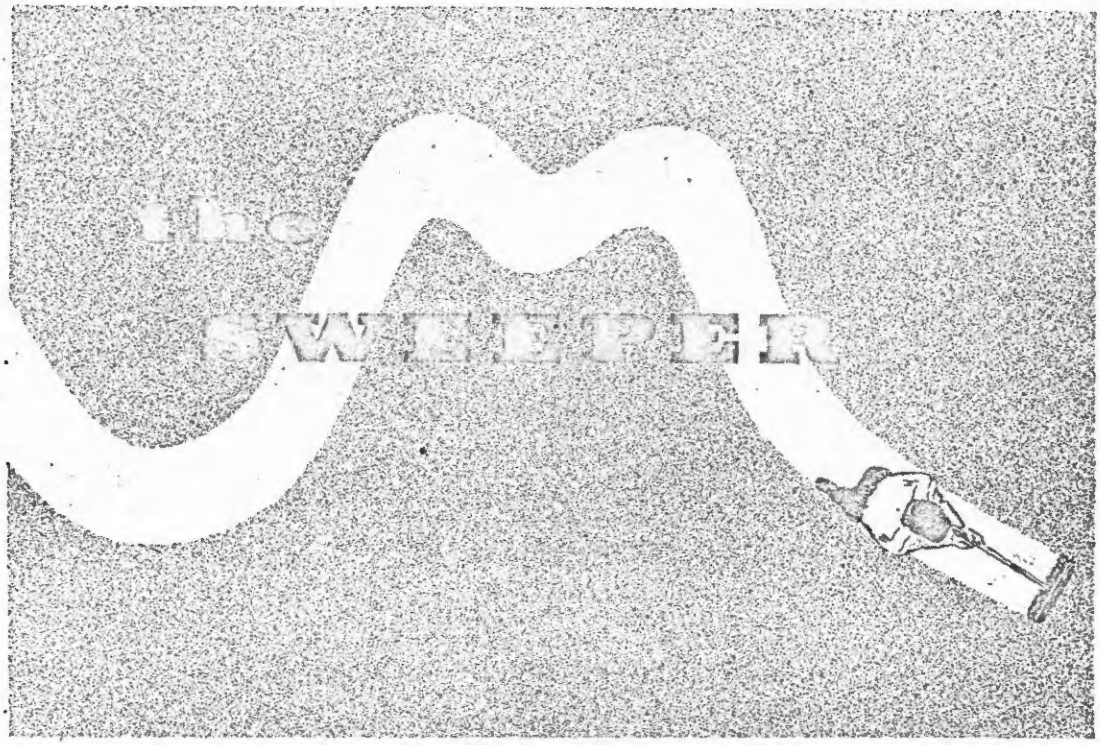


Harold Isenring, W9BTI
4661 N. Lover's Lane Rd.
Milwaukee 16, Wis.

W9BTI comes up with a fool-proof system of measuring SWR in the VHF antenna system. "The Sweeper" is not difficult to build and the cost should be fairly low. VHF men have been on the lookout for something like this for a long time. So here it is boys, get those beams and antennas doing what they're supposed to.

Any amateur, accustomed to precise and careful measurements of RF in our DX bands, will experience a sense of frustration when he first invades the portion of the spectrum above 50 Mc.

In this domain he finds that the common commodities such as r-f voltage, current, standing-wave-ratio, reactance and resistance do not readily submit to the normal procedures of measurement with which he has been familiar. Since Voodoo is frowned upon in the best amateur circles it is evident that the VHF man needs a new tool to furnish him quantitive data and to aid in evaluating the performance of the apparatus he builds and uses. This is where the SWEEPER enters the picture.

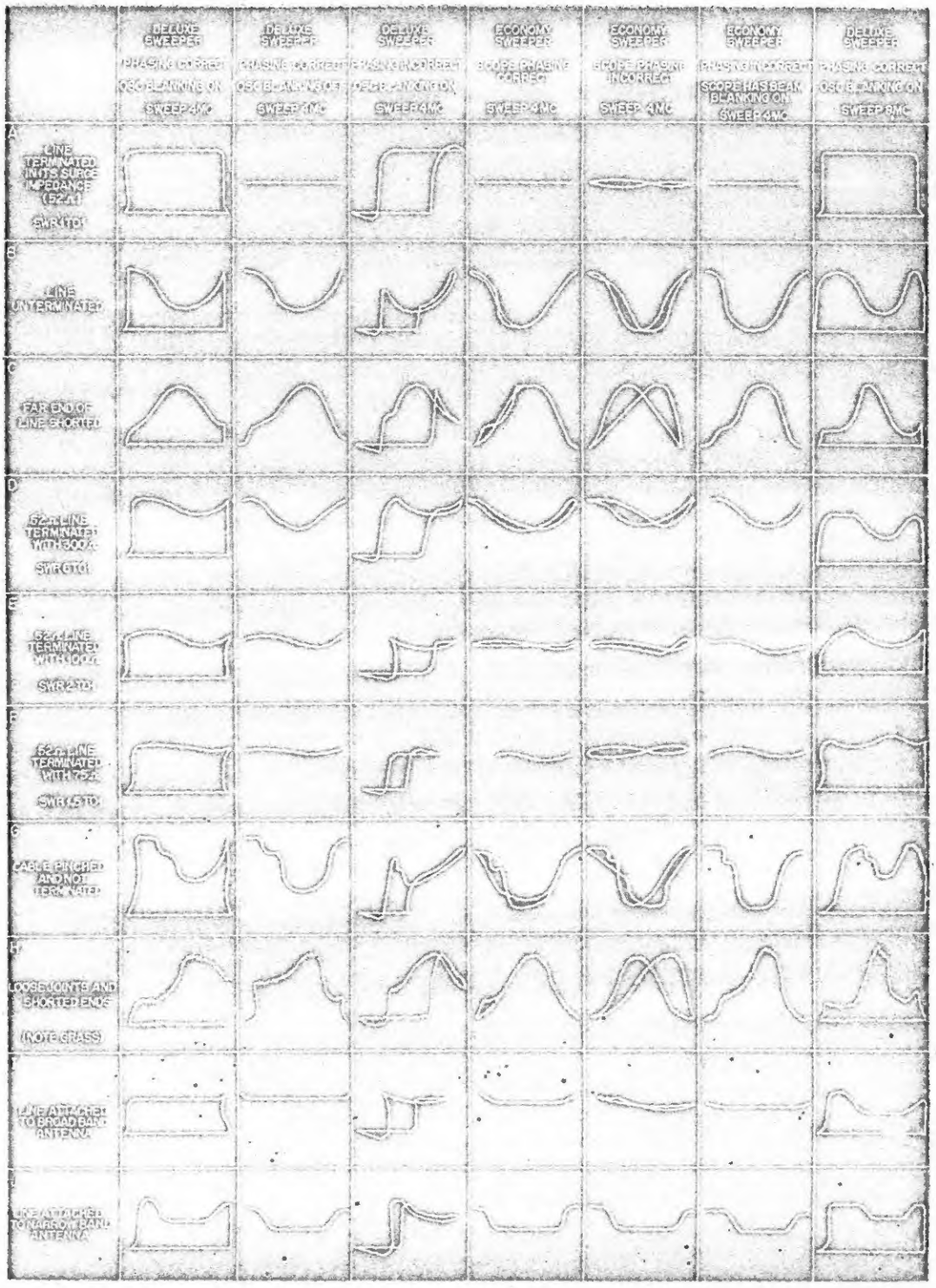
The SWEEPER's effectiveness begins in the vicinity of 50 mc. and improves as the frequency goes higher. The method can be used in all of the VHF bands although the unit to be described was designed particularly for operation in the 144 mc. region. Tuned plate lines are employed whose lengths may be altered for measurements in the 50, 144, 220 or 420 mc. bands. Below 50 Mc. the line lengths become unwieldy.

The adaptability of this instrument for making all sorts of difficult measurements will gradually grow upon you. Some of its uses are:

- **Measuring the input impedance of a receiver**
- **Finding the characteristic impedance of unmarked cables**
- **Finding a kink or defect in a cable**
- **Location of a noisy connection in a line.**
- **Checking dummy loads for transmitters**

Theory of operation

Let us consider the transmission line for a moment. If one end is terminated with a non-reactive resistance equal to the surge impedance of the line, regardless of the frequency the other end will "see" the same impedance. If, on the other hand, the far end of the line is left open, the impedance that the input end "sees" will depend on the length of the line and the input frequency. As an example: a frequency that would make the open line an even number of quarter waves long, would produce a high impedance at the input end. If the frequency were such as to make the line an odd number of quarter waves, the input impedance would be near zero. Shorting the output end would cause the opposite effect in the two examples.



Typical scope patterns for the "Deluxe" and "Economy" SWEEPERS, giving a direct visual indication of impedance variation over a 4-Mc band.

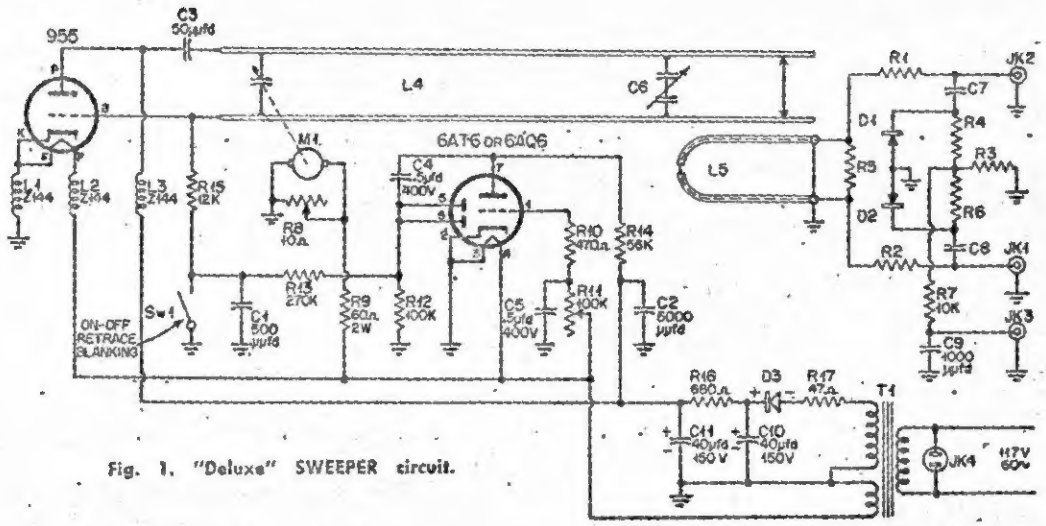


Fig. 1. "Deluxe" SWEEPER circuit.

All resistors ½w. unless otherwise specified.

R1, R2, R5—100 ohm 5%
R3—100K, 10%
R4, R6, R7—10K, 10%
R8—10-ohm wire-wound, 5 watts
R9—60 ohm, 2 watt
R10—470 ohm, 10%
R11—100K potentiometer
R12—100K, 10%
R13—270K, 10%
R14—56K, 10%
R15—12K, 10%
R16—680K, 2 watt, 10%
R17—47 ohm, 10%
L1, L2, L3—Z144 r-f choke
L4, L5—see diagram
C1—500 µµfd. ceramic
C2—5000 µµfd. ceramic
C3—50 µµfd. silver mica button
C4, C5—0.5 µfd. 400V
C6—5-plate Butterfly from SCR522
C7, C8—500 µµfd. silver mica button
C9—1000 µµfd. ceramic
C10, C11—40-40 µfd. 150V electrolytic
D1, D2—IN64 or CK710 diode
D3—35 ma. selenium
J1—SO239 coax panel receptacle
J2—UG-58/U panel receptacle
J3—phono jack
M1—Sweep capacitor-motor assy. from APN-1
T1 — Power transformer, 6.3v. @ 1 amp., 100v. @ 35 ma., primary 117V—TV booster type

Varying the input frequency uniformly from one which makes the input end of the line appear as an even number of quarter waves to one which makes it an odd number of quarter waves would result in the input impedance varying uniformly from extremely high to very nearly zero. We shall take advantage of this phenomenon as the basis for the operation of the SWEEPER.

The Circuit

Basically the SWEEPER consists of a VHF oscillator employing a 955 tube and a set of tuned lines (This ought to be duck soup for those lads tinkering with modulated-oscillator transmitters in pre-WW-II days). The tuned lines are bridged by the sweep motor removed from a surplus APN-1 altimeter. About .25 volts is required by the motor to sweep a 4 Mc. bandwidth. This a-c voltage is furnished by the filament winding of the power supply

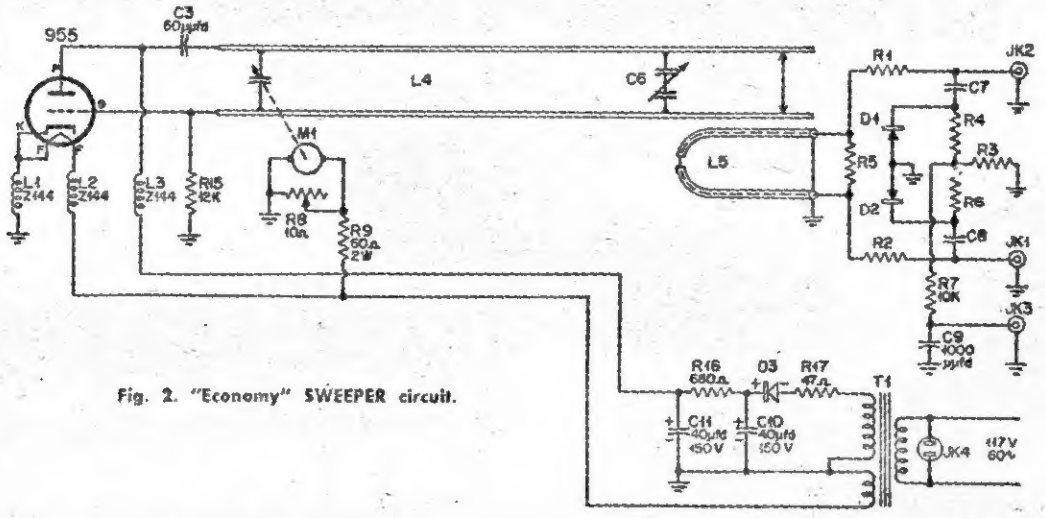
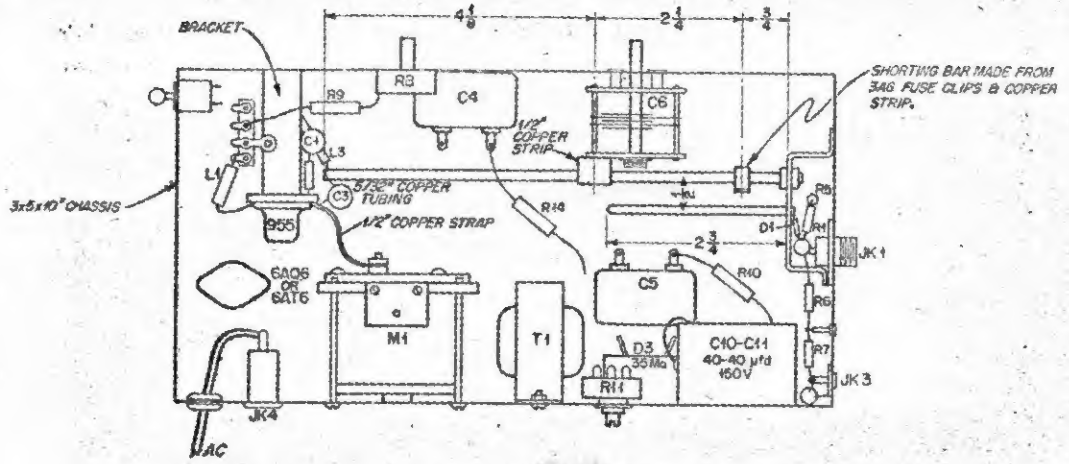


Fig. 2. "Economy" SWEEPER circuit.



Chassis layout of the SWEEPER.

and is regulated by R8, the sweep control. The total range available in this particular configuration is from zero to about 8 Mc. A phase control is in the circuit to start the sweep at any point along the oscilloscope trace, making possible the use of practically any type of 'scope.

Coupled to this variable-frequency oscillator is a shielded link conveying a portion of the picked-up high frequency energy to the output coaxial fittings, into which the circuit or device being measured is connected. Series resistance *R1* and *R2* and shunt resistor *R5* keep the loading on the oscillator relatively constant despite fluctuations in the connected load. A shunt diode system converts the varying r-f voltage to a varying d-c voltage which is presented to the vertical input terminals of the oscilloscope.

The 'scope has its horizontal deflection set to the 60-cycle line frequency so that the spot is swept in unison with the frequency variation of the oscillator. A pure resistance equal to the impedance of the line bridged across the end of the line will present a constant r-f voltage at the detector, giving a straight horizontal line on the 'scope. Any impedance irregularity in the load will appear as a curvature in the horizontal line on the oscilloscope. The table gives an idea of the cathode ray display to be expected from certain types of transmission line conditions. A line mismatch will appear as a sine wave whose amplitude depends on the degree of mismatch.

Two circuit diagrams are shown for the SWEEPER. The Deluxe version includes retrace blanking and a slightly different 'scope presentation although the accuracy is equal in both.

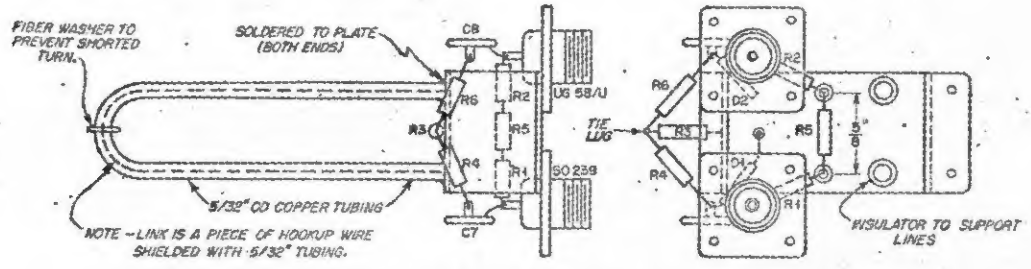
Construction

The SWEEPER can be built into almost any type of box or instrument case, the original being in a utility box measuring 10 x 5 x 3 inches. The only part of the layout that is critical is the oscillator and its output circuit. A reasonable amount of care should be used in this part of the job. Parts placement should be such that short leads result. Short leads should also be used in the assembly of the diode detectors, pickup link and any terminating resistors, also the grounding of the co-ax connectors.

Test and Calibration

After completion, power is applied, and we are ready to calibrate the unit. Set the tuning condenser *C6* in the middle of its range and set the sweep control to zero. With the station

[*Continued on page 56*]



Details of the SWEEPER tank circuit.

THE SWEEPER

[from page 17]

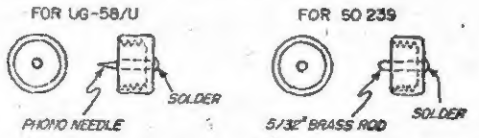
receiver or converter set to 146 Mc. adjust the shorting bars until the output of the oscillator is heard. The main dial on the SWEEPER can now be calibrated against the receiver and should cover considerably more than the two meter band on both sides.

Wherever the dial is set the unit will sweep both sides of this center frequency, the amount of sweep depending on the setting of the sweep control. A sweep of 4 Mc. seems to be best.

Operation

By following the tables you can get an idea just what is taking place in your antenna system. When you think it is set as flat as you can get it, turn the sweep rate to zero and listen for the oscillator signal in a calibrated receiver. The spot indicated on the receiver dial is the center frequency of your antenna system. If it is not where you want it a change can be made in the elements and matching system to bring the center frequency where it should be.

The oscilloscope is coupled to the SWEEPER through a piece of shielded cable to the phono jack provided. Two types of co-ax connectors are provided to give the instrument greater versatility. The unused co-ax conector should always be covered and grounded.



When 300-ohm line is used remove both shorting covers and connect one side of the line to each co-ax connector. Open wire line and 300-ohm ribbon should be kept as far as possible from surrounding objects and excess length may not be coiled up. Excess lengths of co-ax may be coiled up providing no sharp bends are made in the cable. These sharp bends will show up as impedance irregularities in the display.

The 'scope gain should be set so the sine wave, resulting from an impedance mismatch, takes up about two-thirds of the screen height. If the gain is insufficient a larger trace may be had by tighter coupling of the link to the plate lines, by an increase in the value of *R5* or its complete removal. This last is not to be recommended, if it can be avoided. Adjust the horizontal gain until the trace just fills the screen.

With the 'scope and all adjustments on the SWEEPER set, you are ready to proceed with the antenna adjustment. The adjustments will become more familiar after the SWEEPER is around the shack awhile.